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10/688,521	10/17/2003	Robert P. Meagley	ITL.1026US (P16713)	2105
21906	7590	11/30/2006	EXAMINER	
TROP PRUNER & HU, PC 1616 S. VOSS ROAD, SUITE 750 HOUSTON, TX 77057-2631			WALKE, AMANDA C	
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**BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES**

Application Number: 10/688,521
Filing Date: October 17, 2003
Appellant(s): MEAGLEY ET AL.

Timothy N. Trop
For Appellant

EXAMINER'S ANSWER

MAILED
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GROUP 1700

This is in response to the appeal brief filed 9/18/2006 appealing from the Office action mailed 6/29/2006.

(1) Real Party in Interest

A statement identifying by name the real party in interest is contained in the brief.

(2) Related Appeals and Interferences

The examiner is not aware of any related appeals, interferences, or judicial proceedings which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

(3) Status of Claims

The statement of the status of claims contained in the brief is correct.

(4) Status of Amendments After Final

The appellant's statement of the status of amendments after final rejection contained in the brief is correct.

(5) Summary of Claimed Subject Matter

The summary of claimed subject matter contained in the brief is correct.

(6) Grounds of Rejection to be Reviewed on Appeal

The appellant's statement of the grounds of rejection to be reviewed on appeal is correct.

(7) Claims Appendix

The copy of the appealed claims contained in the Appendix to the brief is correct.

(8) Evidence Relied Upon

6,582,891	HALLOCK et al.	6-2003
6,709,807	HALLOCK et al.	3-2004
2004/0198066	VERHAVERBEKE	10-2004

(9) Grounds of Rejection

The following ground(s) of rejection are applicable to the appealed claims:

Claims 1, 3, and 6-12 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hallock et al (6,582,891 or 6,709,807) in view of Verhaverbeke (2004/0198066).

Hallock et al disclose a process for reducing roughness from a surface of a patterned photoresist. The process includes exposing a substrate having the patterned photoresist thereon to a vapor, wherein the vapor penetrates into and/or reacts with the surface of the photoresist. The substrate having the patterned photoresist thereon is then heated to a temperature and for a time sufficient to cause the surface of the photoresist to flow and/or react with the vapor wherein the surface roughness decreases. Optionally, the substrate is exposed to radiation during the process to increase the etch resistance of the photoresist and/or facilitate the reaction of the vapor with the surface of the photoresist. There exists a need for a process for reducing the degree of edge roughness in patterned resist features without significantly affecting the critical dimensions of the feature. It is desirable that the process be extendable to those photoresists used to pattern features less than 250 nm, i.e., photoresists optimized and sensitive for exposure to activating radiation at wavelengths of 248 nm, 193 nm, 157 nm and the like. Moreover, it is desirable that the process be amenable to reducing edge roughness in positive tone photoresists as well as negative tone photoresists. Importantly, the process should be economical, easily implemented and not dependent upon the source or causal factors of the edge roughness. Optionally, the process further includes exposing the photoresist to activating radiation for a time and energy sufficient to increase an etching resistance of the photoresist prior to, simultaneous with or subsequent to exposing the photoresist to the vapor. The radiation that is used to expose the

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photoresist has a wavelength in the ultraviolet range, x-ray range or includes electrons generated from an electron beam, or the like. The vapor can be selected from a material that is reactive or nonreactive during the process. Preferably, the vapor is generated from a material with a boiling point less than about 200 degrees C at standard atmospheric conditions. Examples of suitable non-reactive vapors include ketones and esters such as acetone, methyl ethyl ketone, butyl acetate, ethyl lactate and propylene glycol methyl ether acetate. In another embodiment, the process for reducing edge roughness includes exposing a substrate having a patterned photoresist thereon to a reactive vapor. The reactive vapor diffuses into the surface of the photoresist and lowers the glass transition temperature at the surface exposed to the vapor. The substrate is heated to a temperature and for a time sufficient to cause the surface of the photoresist to flow wherein the surface roughness decreases. During the process, the patterned photoresist is exposed to an activating radiation prior to, simultaneous with or subsequent to exposing the substrate to the vapor wherein the activating energy reacts with the photoresist to generate a compound. The vapor reacts with the compound and adds mass to the photoresist. The compound is reactive with the vapor and is preferably, a free radical, a photoacid generator, a photobase generator, or the like. The vapor may be reactive or nonreactive with the photoresist depending on the choice of material selected to generate the vapor. In the case of a non-reactive vapor, the vapor penetrates into the surface of the photoresist and is believed to lower the glass transition temperature (T_g) at the surface of the photoresist such that the surface T_g is lower than a glass transition temperature for a bulk of the photoresist. That is, the surface T_g is lower than the T_g for the photoresist that was not exposed to any vapor. Subsequent heating of the photoresist at a temperature at or above the surface T_g causes the surface of the photoresist to

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flow and smooth out the surface irregularities. The flow of the photoresist can be controlled on a microscopic scale based on the parameters and materials selected for the process. That is, the depth of penetration of the solvent in the surface of the photoresist can be controlled and limited to the depth of the surface of irregularities such that subsequent flow of the exposed areas renders the surface smooth. It is preferred that the temperatures selected for selectively flowing the photoresist surface are below the T_g of the bulk photoresist or are for a time such that flow of the bulk photoresist is minimal and does not deleteriously affect the targeted critical dimension of the photoresist feature. The temperature used for heating the photoresist surface may be constant or variable. Typically, the temperatures used for flowing the photoresist surface are from about 20 degrees C to about 250 degrees C. The total time and temperature used is dependent on the photoresist thermal properties and the determination thereof is well within the skill of those in the art to optimize. The particular components of the non-reactive vapor are selected by their ability to form a vapor at vapor forming conditions and their ability to penetrate into the surface of the photoresist. Accordingly, the vapor can be a single material or a mixture generated from a solid, liquid or gas. Preferably, the vapor is a solvent or co-solvent for the polymer used in the photoresist. However, in some cases, it is desirable and advantageous to employ a material with which at least one of the components in the photoresist is only marginally soluble or miscible. It has been found that this will help control the extent of vapor penetration and subsequent plasticization. The solid, liquid and/or gas materials are exposed to a temperature and/or pressure sufficient to maintain the selected material in its vapor phase. The range of vapor pressures suitable for use in the present invention is in a range from about 1 atm to about 760 atm. In practice, preferred materials are liquids with a boiling point less than 200.degree. C. at

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standard atmospheric pressure. Examples of suitable solvents for forming the vapor include, but are not limited to, ketones such as acetone, methyl ethyl ketone, and esters such as butyl acetate, ethyl lactate and propylene glycol methyl ether acetate. Other materials suitable for use in the present invention will be apparent to one skilled in the art in view of this disclosure. Exposure to the vapor may be limited by time and/or by concentration (vapor pressure). The effect of such permeation and penetration into the surface of the photoresist will be to selectively lower the T_g at the surface via a plasticization of the polymer chains. Solvent plasticization is a well-known phenomena known to those skilled in the art to lower the T_g of polymers. This in turn will allow the polymer chains to flow in the vapor-permeated region at a lower temperature than that of the bulk resist.

Hallock et al fails to teach the use of a supercritical fluid after development.

Verhaverbeke teaches to add a step of using a supercritical fluid to dry the surface of the substrate/-pattern after development. The supercritical fluid includes, but are not limited to, carbon dioxide, xenon, argon, helium, krypton, nitrogen, methane, ethane, propane, pentane, ethylene, methanol, ethanol, isopropanol, isobutanol, cyclohexanol, ammonia, nitrous oxide, oxygen, silicon hexafluoride, methyl fluoride, chlorotrifluoromethane, water, and combinations thereof. Furthermore Supercritical fluids and/or dense fluids, such as carbon dioxide, may be used to advantage in processing a variety of materials used in semiconductor applications. For example, supercritical fluids and/or dense fluids are useful in processing of porous low-k materials. Examples of porous low-k materials include organosilanes or organosiloxanes, such as Black Diamond.TM., available from Applied Materials, Inc. of Santa Clara, Calif.; organo-silicate-glass (OSG); tetraethylorthosilicate (TEOS); methylsilsesquioxane (MSQ); hydrido

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silsesquioxane (HSQ); MSQ-HSQ copolymers; silsesquioxane HOSP; other Si-containing material; other porous polymers; and any other suitable material. Preferably, the porous low-k materials comprise an organosilanes or organosiloxanes. Depending on the application, other optional components, such as co-solvents, surfactants, chelating agents, reactants, and combinations thereof, may be used in conjunction with the supercritical fluid and/or dense fluid. Examples of co-solvents include, but are not limited to, alcohols, halogenated solvents, esters, ethers, ketones, amines, amides, aromatics, aliphatic hydrocarbons, olefins, synthetic and natural hydrocarbons, organosilicones, alkyl pyrrolidones, paraffins, petroleum-based solvents, other suitable solvents, and mixtures thereof. The co-solvents may be miscible or immiscible with the supercritical fluid and/or dense fluid. Examples of chelating agents include, but are not limited to, chelating agent containing one or more amine or amide groups, such as ethylenediaminetetraacetic acid (EDTA), ethylenediaminedihydroxyphenylacetic acid (EDDHA), ethylenediamine, or methyl-formamide or other organic acids, such as iminodiacetic acid or oxalic acid. The term "surfactants" as used herein includes compounds have one or more polar groups and one or more non-polar groups. It is believed that the surfactants help alter the interfacial characteristics of the supercritical fluid and/or dense fluid. Examples of reactants include, but are not limited to silicon-containing compounds, oxidizing agents, carbon-containing compounds, other reactants, and combinations thereof. These are listed as plasticizers in the instant specification.

Given the teachings of the references, it would have been obvious to one of ordinary skill in the art to prepare the material of Hallock et al choosing to dry the pattern/ substrate post

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development of Verhaverbeke with reasonable expectation of achieving a pattern having reduced line edge roughness.

(10) Response to Argument

Appellant has argued that there is no motivation to combine the Hallock and Verhaverbeke references as the Verhaverbeke reference “has nothing to do with a photoresist”. The examiner respectfully disagrees. Firstly, the examiner notes that Hallock et al teach a method of reducing line edge roughness in a patterned photoresist (the same problem the instant application is aiming to solve), and teaches all of the steps of the instant method with the exception of applying a plasticizer in supercritical fluid after development, but before the reflow step. Verhaverbeke clearly relates to a patterning process employing a photoresist material and/or other polymeric materials. As described in paragraphs [0056]-[0060] and figure 7, the reference discusses employing a supercritical fluid (which may contain solvents as described above) to develop or cure a layer of photoresist. Additionally, as discussed above, the reference teaches that the *supercritical fluid may be employed in a drying step after development/wet cleaning of a patterned substrate*. The photoresist would act like a sponge and some of the developing solution would remain in the patterned resist material, thus the drying step is performed ([0043]-[0047]). Thus it is the position of the examiner that one of ordinary skill in the art would have been motivated to employ a drying step as described by Verhaverbeke in the method of Hallock et al after development. Furthermore, it is the position of the examiner that one of ordinary skill in the art would have been motivated to perform the development step of

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Vahaverbeke employing a supercritical fluid and co-solvent as the development step of Hallock (which is taught to be any known developing method).

Appellant has also argued that the references do not teach that a plasticizer would be absorbed into the resist during the drying step. Verhaverbeke clearly teaches the use of a plasticizer in a supercritical fluid (carbon dioxide with a co-solvent such as alcohols, esters, ketones, amines, and amides [0024]), and solvents are taught on pages 6 and 7 of the instant specification to be suitable plasticizers. When the drying step is performed, the application of the fluid would cause some of it to be absorbed into the resist pattern. Hallock et al clearly teaches a method of patterning a photoresist including a reflowing step after development to reduce the line edge roughness of the pattern (see abstract of Hallock), thus when the drying step of Verhaverbeke employing a supercritical fluid and co-solvent is employed as the drying step in the method of Hallock et al, the method would meet the limitations of the instant specification.

As the examiner has presented a clear and reasonable position based on the teachings of the two references, and demonstrated that the references obviate the presently claimed invention, the examiner maintains her position despite the Appellant's arguments.

For the above reasons, it is believed that the rejections should be sustained.

(11) Related Proceeding(s) Appendix

No decision rendered by a court or the Board is identified by the examiner in the Related Appeals and Interferences section of this examiner's answer.

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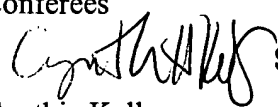
Respectfully submitted,

Amanda C Walke
Primary Examiner
Art Unit 1752

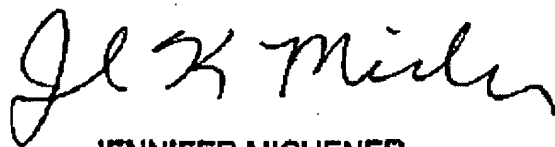
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November 20, 2006

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Cynthia Kelly

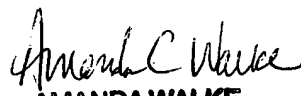
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